

CHAPTER 8

UPGRADING EXISTING TREATMENT FACILITIES

8-1. General.

Upgrading of wastewater treatment plants may be required to handle increased hydraulic and organic loadings to meet existing effluent quality or to meet higher treatment requirements. Any of these situations requires optimization of existing facilities before consideration of additional treatment facilities. It is necessary that a distinction be made between upgrading to accommodate higher hydraulic and organic loads, and upgrading to meet stricter treatment requirements. Existing facilities can be made to handle higher hydraulic and organic loads by process modifications, whereas meeting higher treatment requirements usually requires significant expansion and/or modification of existing facilities. Additional information may be found in the EPA Manual **Process Design for Upgrading Existing Wastewater Treatment Plants**.

8-2. Techniques for upgrading existing sedimentation facilities.

Improved solids separation in primary and secondary settling tanks or clarifiers results in concurrent reduction of biochemical oxygen demand levels in the tank effluent. Solids separation can be enhanced by adding more clarification capacity, either by chemical treatment of the wastewater or by use of more efficient settling devices. Upgrading the primary clarifier has the advantage of decreasing the organic loading and thus reducing the amount of secondary sludge produced in the biological treatment units. Furthermore, more solids will be selected and removed with the primary sludge, which is thicker and more amenable to dewatering than secondary sludge. The secondary clarifier in a biological treatment process determines the overall plant efficiency because it removes the organic matter that is converted from a soluble to an insoluble form in the biological units.

a. Addition of chemicals. Chemicals may be added to the primary settling tank as a means of upgrading performance and relieving organic overloading in wastewater treatment plants; but it is not normal practice to add chemicals to secondary clarifiers since aerobic biological sludge flocculates and settles readily when normal growth conditions are maintained, i.e., sludge retention times are optimized. Lime addition to an activated sludge secondary clarifier may not be feasible because of the potential adverse effect of recirculated lime sludge on the microbiological characteristics of mixed liquor. Moreover, lime addition generally requires pH adjustment of the effluent before further treatment or discharge to the receiving waters. When considering the addition of chemicals to primary clarifiers, it is important to examine the effect of increased primary clarifier efficiency on subsequent treatment units. If the biochemical oxygen demand load in the biological aeration basin falls below 0.25 to 0.35 pound biochemical oxygen demand per pound of mixed-liquor, volatile suspended solids per day because of increased primary clarifier efficiency, nitrification conditions may prevail. This can reduce the total oxygen demand of the effluent but, at the same time, it will increase the oxygen demand on the aeration facilities. A decrease in loadings in the aeration basin will also require more careful sludge handling to ensure stable conditions. Chemical addition to the primary clarifier may produce more sludge; therefore, sludge handling facilities must be evaluated to ensure proper capacities and loadings.

b. Tube settlers. Shallow-depth settling systems such as tube settlers have been used, to a limited extent, in primary and secondary clarifiers to improve performance as well as to increase throughput in existing tanks. These settlers capture settleable solids at higher than normal overflow rates. However, they do not improve the efficiency of primary clarifiers that are already achieving high degrees of suspended solids removal (40 to 60 percent). Moreover, they will neither remove colloidal solids that remain in suspension nor induce additional coagulation to bring about additional particle removal. The design of shallow-depth settling systems will be based on pilot studies of the waste liquid for which solids settling is required. Approval for their design criteria and use must be obtained from HQDA (CEEC-EB) WASH DC 20314-1000 for Army projects and HQ USAF/LEEE WASH DC 20332 for Air Force projects. For more information regarding tube settlers, refer to the EPA **Process Design Manual for Suspended Solids Removal**.

8-3. Techniques for upgrading existing trickling filter plants.

a. **Upgrading to relieve organic and hydraulic overloading.** Trickling filter plants may be upgraded to relieve hydraulic or organic overloading by the construction of additional trickling filters in parallel with existing units or by any one of the following four procedures:

(1) **Conversion of low-rate trickling filters to high-rate trickling filters.** The first step in this procedure is to evaluate the quantity of recycled flow to be returned ahead of the filter. This can be accomplished by using trickling filter formulae. Such an upgrading technique may require changing or motorizing the existing distributor arm to handle the new hydraulic loading to the upgraded filters.

(2) **Conversion from a single-stage to a two-stage filtration system.** Low and high-rate trickling filters that are overloaded can also be upgraded by converting them to two-stage filtration systems. This type of upgrading, in which a complete set of units is added, is far less complicated than a renovation of existing tankage. The most important consideration is that sufficient hydraulic head has to be available to operate the individual unit processes.

(3) **Conversion of single-stage trickling filter to two-stage biological system.** An overloaded high-rate trickling filter can be upgraded by replacing existing stone with synthetic media. Synthetic media have been found to have the following advantages over conventional filters: higher allowable hydraulic loadings; low energy consumption; reliable performance; resistance to hydraulic and organic shockloads; simple operating procedures; and reduction in sludge bulking problems. Another upgrading technique is to install a second high-rate filter in the treatment train.

(4) **Upgrading an existing two-stage trickling filter.** The following options are available for upgrading an overloaded two-stage filter:

- Construction of a roughing filter preceding the existing system.
- Construction of a separate biological treatment system parallel to the existing facilities.

b. **Upgrading to increase organic removal efficiency.** The selection of an upgrading technique is based on the ability of the existing facilities to handle increased hydraulic or organic loads. Modifications are provided to meet higher effluent standards even though the existing facilities are not hydraulically or organically overloaded. Table 8-1 contains approved alternatives for improving effluent quality under these conditions and suggests anticipated improvements in performance for each alternative. In cases where unit processes are added to existing facilities, it must be emphasized that the improvement in overall organic removal will be a direct function of the biochemical oxygen demand removal achieved in the new downstream unit process. Where unit processes precede existing units, however (such as with the use of a roughing filter), the overall biochemical oxygen demand removal may not be increased in direct proportion to the amount achieved in the “add-on” process. A detailed discussion on polishing lagoons, microscreens, filters, activated carbon, clarifiers, and land treatment modifications appears in subsequent chapters. The applicability of each alternative in individual upgrading cases should be evaluated in detail in a feasibility study.

Table 8-1. Trickling filter plant upgrading techniques.

Modification to Existing Unit	Additional Preceding Existing Unit	Addition Following Existing Unit	Incremental BOD Removal Across the Added Unit Percent
	LOW-RATE TRICKLING FILTER		
	Add recirculation during low-flow periods.		0-10
	HIGH-RATE TRICKLING FILTER		
	Increase recirculation.		0-10
	TWO-STAGE TRICKLING FILTER		
Roughing Trickling Filter ¹ (Rock or Synthetic Media)			20-40
Chemical Addition to Primary Clarifier			30-50
		Biological Disk ²	30-50
		Wastewater Treatment Pond ³	30-60
		Multi-media Filters	50-80
		Microstraining	30-80
		Activated Carbon	60-80
		Land Treatment	85-95

¹Generally not amenable to modifications for increasing treatment efficiency.

²A consideration if year-round nitrification is required.

³Algae growth may exceed effluent suspended solids limitations and filtration may be required to meet effluent limitations.

8-4. Techniques for upgrading conventional activated sludge plants.

a. Upgrading to relieve organic and hydraulic overloading. When upgrading, make sure that the increased sludge production resulting from these modifications is considered. Table 8-2 contains approved alternatives for upgrading activated sludge plants

Table 8-2. Activated sludge plant upgrading techniques.

Addition Preceding Existing Unit	Addition Following Existing Unit	Incremental BOD Removal Across the Added Unit Percent
Roughing Trickling Filter (Rock or Synthetic Media)	2nd Stage Activated Sludge	20-40
	Polishing Lagoon	30-50
Chemical Addition to Primary Clarifier	Multi-media Filters	30-70
	Microstraining	30-60
	Activated Carbon	50-80
	Land Application	30-80
		60-80
		85-95

(1) **Step-aeration.** This type of upgrading generally involves only minimum capital investment. To implement this type of upgrading, it is necessary to modify influent piping, renovate the air system, and expand the sludge recycle capacity. Primary and secondary clarifier capacity must be checked and increased to handle the higher loadings.

(2) **Contact stabilization.** An overloaded, conventional activated sludge plant can be upgraded by converting the existing aeration tank to two separate tanks: one for stabilization of return sludge and the second as the contact tank for the raw wastewater. In addition to the physical conversion of the single aeration tank to two tanks, this type of modification requires revamping the influent piping, expanding the sludge recycle capacity, and installing new aerators. Expanding the secondary clarifier capacity can be achieved, in many cases, by introducing the raw wastewater directly to the stabilization tank and operating in parallel with the secondary clarifier.

(3) **Completely mixed activated sludge.** The flow in a conventional aeration tank can be modified to provide for uniform distribution by changing the influent wastewater piping and the recycle piping. Complete mixing in the tank can be achieved through installation of an agitator sparger air system.

(4) **Oxygen aeration.** An overloaded, conventional activated sludge plant can be upgraded by using oxygen instead of air for aeration. The upgrading modifications will include oxygen generation facilities, installation of aeration tank cover and baffles, and new piping arrangements. The structural integrity of the existing aeration tank and foundation must be checked before modification. The design will also include provisions for precautions against explosion and protection against potential accelerated corrosion.

(5) **Use of activated sludge to treat partially treated wastewater** This modification is considered to be the simplest of all upgrading procedures since the activated sludge process will be built as an addition to an existing facility. If nitrification is required, aeration to provide at least 4.5 pounds oxygen per pound of ammonia nitrogen will be provided in addition to the air requirements for carbonaceous biochemical oxygen demand removal. No modifications will be required for the existing facilities, and the additional facilities will be designed as add-on units.

b. Upgrading to increase organic removal efficiency. The increasingly stringent requirements on effluent quality may dictate a need for upgrading even though the existing facilities are not hydraulically or organically overloaded. Table 8-2 contains the incremental biochemical oxygen demand removal percentages that can be achieved at an activated sludge plant by various upgrading modifications.

8-5. Techniques for upgrading waste treatment ponds.

In many cases, ponds have been designed without physical design factors being considered. Therefore, improvements in pond performance can be obtained through physical changes such as installing diversion curtains to prevent "short circuiting." Also, improvements in the inlet and outlet configurations can be effective. In some cases, installation of additional aeration equipment at critical locations in the pond will improve its efficiency. Paragraph 14-3 provides design criteria for aeration requirements. Finally, adequate retention time is essential. Some existing ponds will have a gradual loss of retention time due to solids deposition in quiescent zones. This problem can be corrected through periodic removal of solids from existing ponds.